Geometric

Progressive Display for Efficient Visualization

Eliminating sluggishness of heavy geometry data using progressive display

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WHITE PAPER

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Contents

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Introduction

Efficiencies in 3D visualization of complex and large data have become a growing need of multiple industry sectors today. Professionals involved in scientific research and engineering development today face a number of challenges while dealing with heavy data sets that need to be visualized in 3D formats to enable easier and accurate interpretation, analysis and further processing operations. Often such professionals work in dispersed teams, or need to collaborate with other professionals at remote locations or have constraints with the hardware and computing system capacities leading to significant challenges in making the best use of the data generated by 3D-data-generating devices.

With computing capacities showing significant improvements in the recent past, it is now the turn of software engineering to bring in innovations that will enable improvements in visualization of super heavy 3D geometry data. Progressive Visualization or Progressive Display is one such approach that helps overcome the challenges in 3D visualization in different industrial and research applications.

Recognizing challenges across application areas

Large size of the 3D medical data causes the display application to become unresponsive

In a typical scenario, a medical research professional, who also deals with the software aspect, would scan and digitize 3D data of body parts. A high resolution scanning technology would be adopted with the intention of capturing every detail, resulting in the generation of huge 3D data sets. However, viewing this data using conventional 3D-display software is a challenge. It takes a long time for an object to appear on the screen, and when it does appear, trying to rotate, zoom or pan the 3D object, makes the software jerk or hang. Sometimes the software fails to even load the data, and valuable data remains un-scrutinized.

The surface scanner or aerial survey equipment generates data that is too heavy for the viewer application

The situation is analogous to the field of oil & gas exploration, wherein, huge spatial files of scan data of oil fields and other resources are transmitted. Productivity is hindered because the display software used to analyze the survey data is too slow and sluggish to load and manipulate the 3D data generated by the survey equipment.

Customers complain about the sluggishness of the 3D display capability of commercial products

Software product vendors supplying customized 3D visualization applications to customers receive complaints that products are not scalable to handle more complex and larger 3D data efficiently.

The display technology is unable to shade the 3D objects properly

In some cases, huge 3D data does get loaded, but the user is unable to visualize it properly. There is no proper shading or lighting. This often occurs when the data is very raw with no vertex-normal or face-normal information, which is essential for the rendering module to apply proper shading and lighting. Therefore, the display appears flat with insufficient 3D effect. To work around this, the data could be subject to proper triangulation, vertex-normal and face-normal calculation modules. However the current software does not have such modules; the user is faced with the problem of visualizing a raw data set, which is a huge list of vertices (point clouds) possibly generated by the 3D scanner.

Solid-scan data set needs to be processed, but the display application is meant for surface-scan data

A solid-scanned 3D data set needs to be visualized. This data set is very raw with all the vertices spread in the solid volume. However, a surface-scan based display application does not accept the data for display; or if it does display, it renders the data incorrectly.

Need to collaborate with 3D data across networks

In some cases, the huge 3D data is accepted by the application, allowing the user to visualize it. But if the organization has teams spread across locations that need to collaboratively work on the same data, then this becomes difficult with the current application not supporting network based collaboration.

Huge 3D data puts limitations on conventional displays

Advancements in 3D scanners used in medical imaging and other industries have enabled generation of high-resolution 3D data. However, often this data is huge in size and poses challenges in visualization. Typical medical imaging 3D data sets can be as large as 300 MB to 1 GB; whereas, data sets generated from surveys in oil & gas industries can be to the tune of terabytes.

Conventional display systems try to load the 3D data without any pre-processing. Every vertex in the data is read, loaded into the memory and fed to the rendering module at once. This results in overloading of the load bearing module, RAM and the rendering module, effectively slowing down the application.

What is Progressive Display?

Progressive display visualizes 3D data in progressive steps to mitigate the overload posed by the size of the data. It attempts to solve the problem of visualizing huge 3D data while enabling smooth manipulation of this data. It is, therefore, a very useful tool for all applications that need to handle huge amounts of 3D data.

The basic features of Progressive Display are:

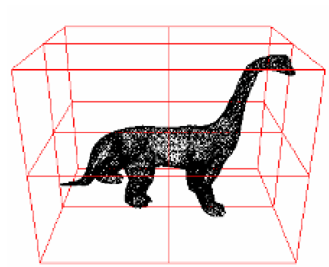
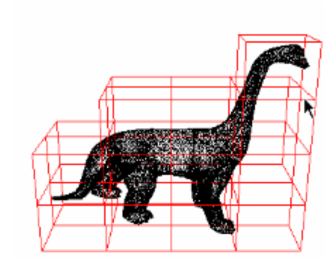
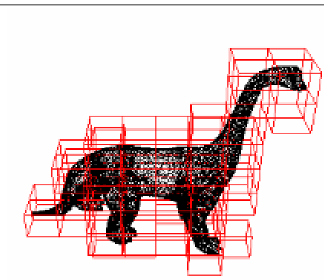
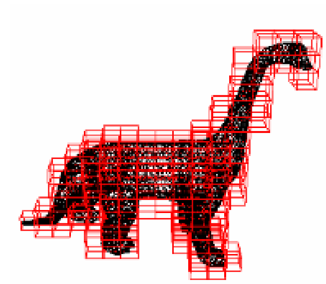
- This display can visualize 3D data in the point cloud form. Point cloud form is the rawest, unprocessed form of 3D data generated by 3D scanners used in most research and industrial applications.
- It can visualize STL data, a very common 3D data format.
- It can render the point cloud with proper shading and lighting, even though the data does not contain vertex normal or face normal information.
- It can visualize both solid-scan 3D data and surface-scan 3D data.
- It visualizes the 3D data progressively, from coarse resolution to fine resolution for the area of interest in the complete data set. Thereby, making the size of the 3D data a less limiting factor.
- This display enables users to interact (rotate, pan or zoom via simple and intuitive mouse moves) with huge 3D data sets, without the system appearing to hang.
- Compared to conventional, non-progressive displays, the speed at which 3D data can be manipulated is higher, especially when the data-size is in excess of 100 MB.

Extended Features of Progressive Display

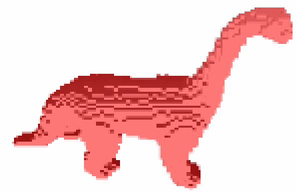
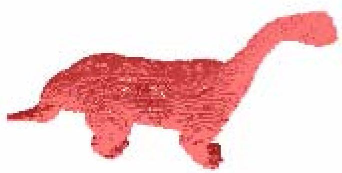
- **Optimization** of progressive display parameters based on the capabilities of the host machine (processor speed, memory capacity, display hardware support)
- **Streaming** of 3D data over a network
- **Real time collaboration** on large 3D data, over a network, through data streaming
- **Visualization** of 3D data in other popular formats

Achieving Progressiveness in Display

A step-by-step user controlled progressive display is obtained from coarse resolution to fine resolution of the area of interest in a complete data set. The entire view-volume in world space is divided into eight equal cubical volumes. If any of the sub-division contains objects to be viewed, it is further divided into eight equal cubical volumes. This is repeated until the objects to be viewed are fully resolved. The user decides the desired resolution of the rendered object.

Progressive space division of view-volume	
	
Iteration 1	Iteration 2
	
Iteration 3	Iteration 4

This pre-processing step is done offline, or while the application encounters a 3D data file for the first time. The result of this space division is that the 3D data or the 3D object gets divided progressively with an increasing level of detail at every step.

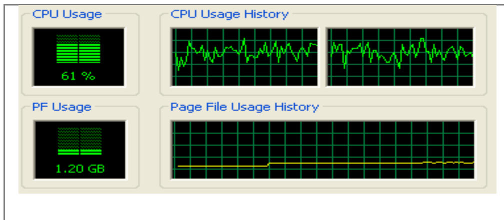
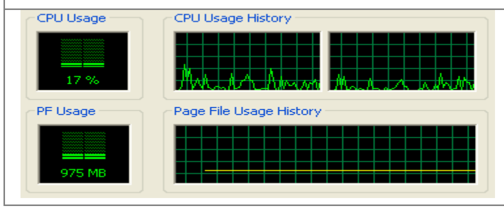
Progressive space division: Impact on the 3D object		
		
Iteration 1	Iteration 2	Iteration 3
		
Iteration 4	Iteration 5	Iteration 6
		
Iteration 7		

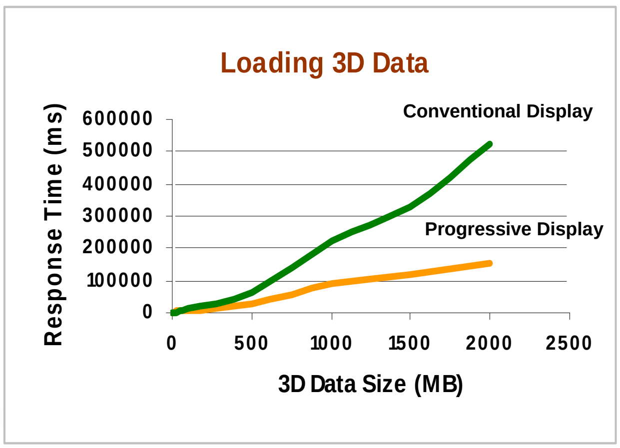
Once the data is pre-processed, the application can visualize it, irrespective of how large it is, in real time. The morphing of the object from the lowest detail to the highest detail will happen in a fraction of a second. Hence, many of the steps (such as iteration 1, 2, 3 or 4) will barely be noticeable to the user as the user seamlessly rotates, zooms or pans the object.

The end result is that, the user is able to load and handle heavy 3D data, just as handling very light weight data.

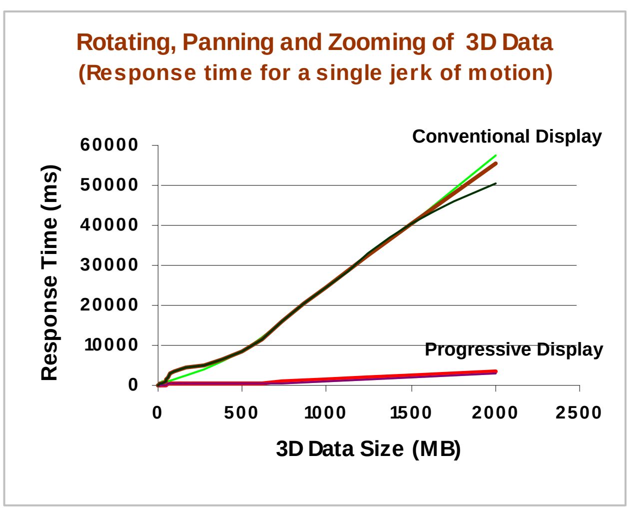
Performance

Progressive visualization uses significantly lower computing power leading to improved application performance and higher user satisfaction.

	**Conventional Application** Performance of a conventional application trying to visualize a huge 3D data file
	**Progressive Display** Performance of Progressive Display application trying to visualize the same 3D data file



Conventional display, can take over ten minutes for proper loading of data beyond 1 GB, and it can fail in between, due to internal problems. Progressive display, on the other hand, takes only three minutes to load such data. Pre-processing of the 3D data can take more time, but this is a one-time activity that takes place only when a file is encountered for the first time. Pre-processing time is excluded from the calculations.

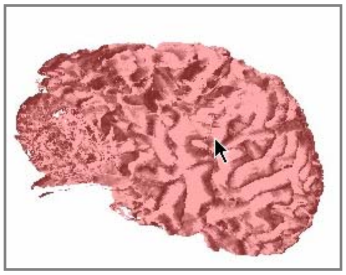


Conventional display takes as much as a minute for every single jerk of motion at gigabyte range of data, taking an agonizingly long time to perform any meaningful rotation, pan or zoom on the 3D data. In case of progressive display, a maximum delay of 3 seconds is recorded for the rotation of 2GB data in the first action from the inertial state, and subsequent actions are smooth. This is expected to come down further by optimizing some of the algorithms.

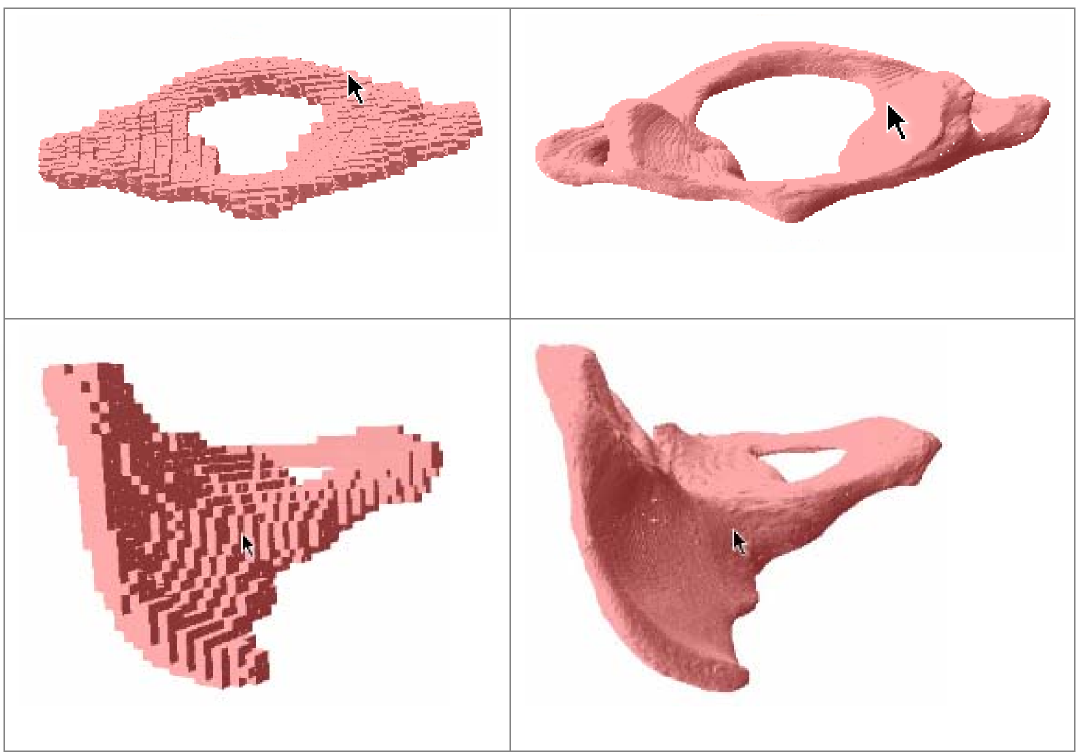
Examples of Potential Applications

Medical Imaging

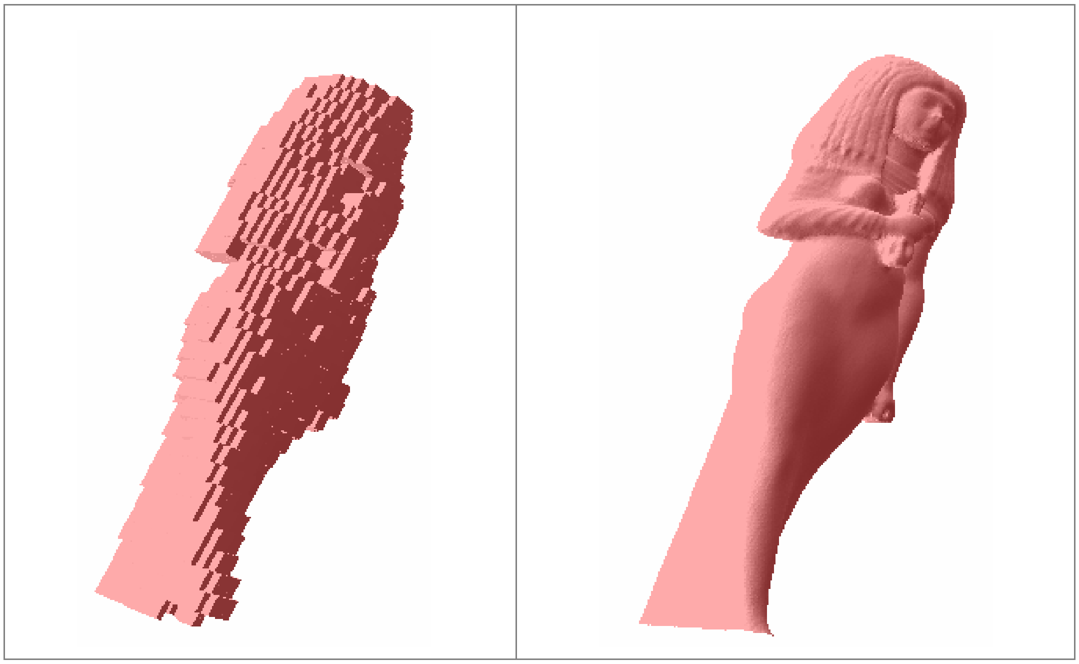
Large 3D data of the human brain (135 MB) loaded, rendered and manipulated (rotated, zoomed, panned) smoothly using progressive display.



Other medical data rendered and manipulated.

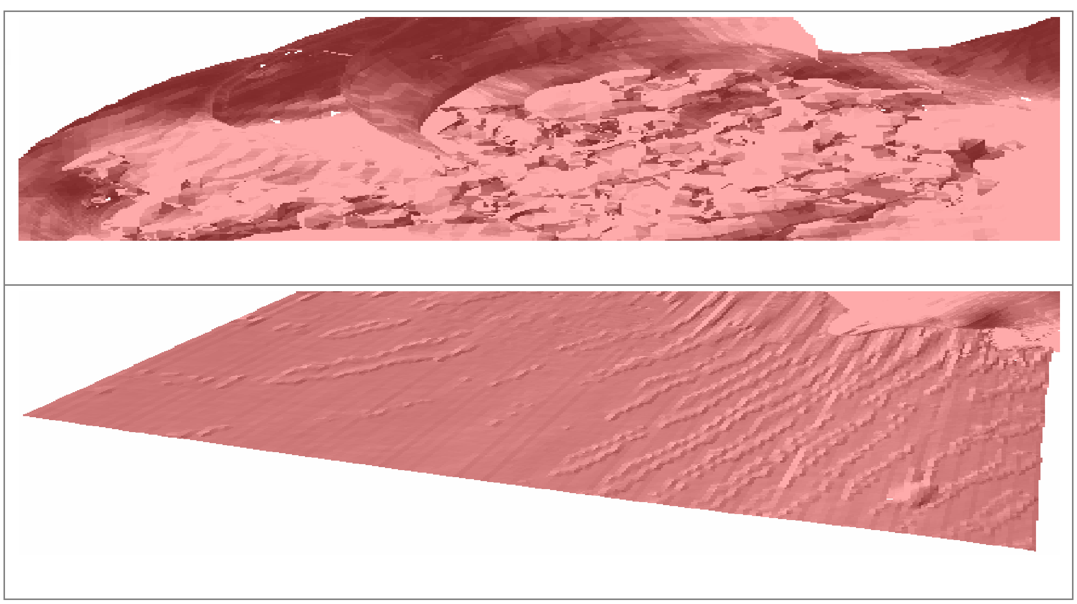


Archeology: Artifact Reconstruction



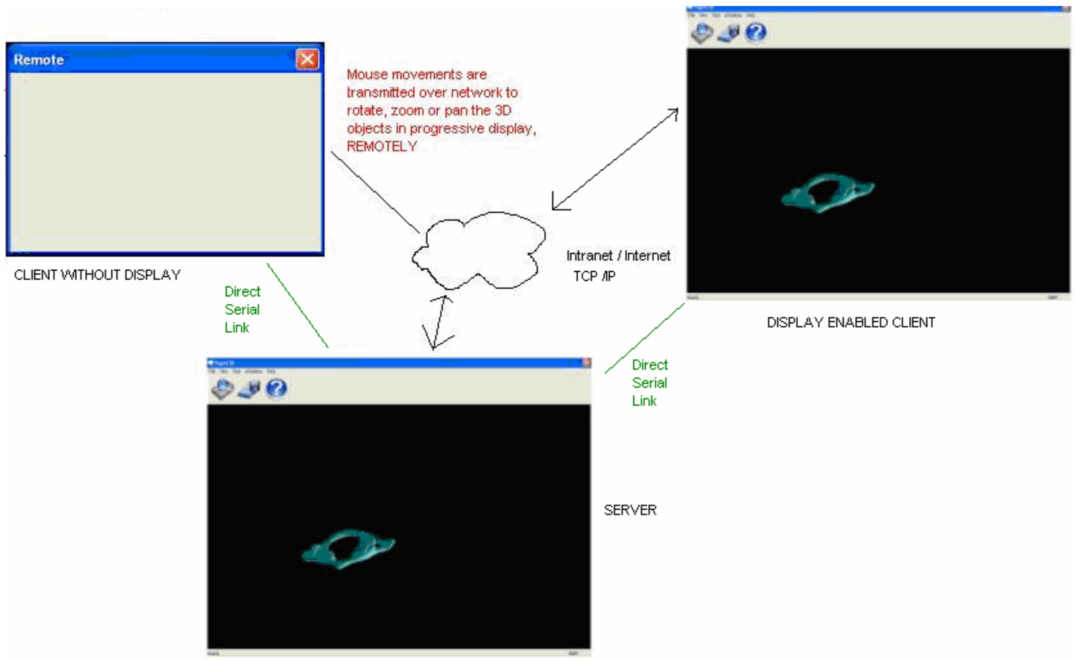
Oil & Gas, Mining, Aerial Survey, Terrain Reconstruction

Progressive display can be used to visualize and manipulate (rotate, zoom and pan) huge 3D data (data size in gigabytes) from oil & gas, mining and aerial surveys.



Network Enabled Collaborative Visualization

Progressive display is also network enabled. It is a handy solution where 3D data is to be manipulated collaboratively across networks.



Conclusion

Progressive display technologies attempt to solve the problem of visualizing large size 3D data, by optimizing the requirement of computing capacities to process and render the data progressively, targeted at the area of interest in the data set. These applications can bring in significant efficiencies in areas like oil & gas, land surveys, and in archeology for artifact scanning which involves a lot of reverse engineering for digital model reconstruction. Progressive display also extends the capabilities of telemedicine applications, by enabling them to handle large 3D image data over remote and wireless mobile devices. The networking capabilities of such applications enable effective collaboration on visualized data over a network. Geometric is working on the optimization of such algorithms which will lead to even shorter response time and faster display rates, with the ability to handle larger data sets in the future.

About the Author

Jijith is a Technical Consultant with the R&D Practice of Geometric. He specializes in visualization technologies, graphics, and gaming engine development. Visual computing, volume reconstruction, creative programming, neural nets are his other areas of interest. Jijith can be reached at Jijith.N@geometricglobal.com

About Geometric

Geometric is a specialist in the domain of engineering solutions, services and technologies. Its portfolio of Global Engineering services and Digital Technology solutions for Product Lifecycle Management (PLM) enables companies to formulate, implement, and execute global engineering and manufacturing strategies aimed at achieving greater efficiencies in the product realization lifecycle.

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